

JASSA



Journal of Applied Science in Southern Africa
The Journal of the University of Zimbabwe

Volume 3, Numbers 1 and 2, 1997

ISSN 1019-7788

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Incidence of bruising and dark firm dry beef in cattle carcasses in a commercial abattoir in Zimbabwe: An animal welfare concern

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The incidence of carcass bruising and occurrence of dark, firm, dry (DFD) beef in slaughter cattle were investigated from a survey of 9585 cattle delivered to a commercial abattoir. The objectives of the study were to evaluate the extent of occurrence of carcass bruising and DFD in slaughter cattle as these have a major impact on economic returns to the beef producer. In addition, these data can be used as indicators of either good or poor welfare of the animals prior to slaughter. In this study, the overall incidence of bruising was 29.6 percent while that of DFD was 27.4 percent. There were differences between the incidences of both bruising and DFD ($p < 0.001$) in carcasses from bulls, steers and cows. Overall, bulls had the greatest carcass damage and steers the lowest. In addition, bruising increased ($r = 0.97$; $p < 0.05$) and the incidence of DFD also increased ($r = 0.94$; $p < 0.05$) with increasing transit distance. Linear regression analysis showed that a sixty kilometer increase in transit distance resulted in a seven percent increment in bruising (equation: $y = 6.9 + 7.1x$; $R^2 = 0.96$; $p = 0.0047$). However, there was no association between bruising and DFD. Among different carcass weights, there was considerable variation in frequency of occurrence of DFD ($p < 0.001$), with the proportion of carcasses showing DFD decreasing as carcass weight increased. The results indicate substantial compromised animal welfare and major economic loss to the entire livestock industry. Further, the results suggest that transit distance appears to contribute substantially to causes of bruising and DFD in slaughter cattle in Zimbabwe.

Keywords: Animal welfare, cattle, carcass bruising, dark-firm dry beef, transport.

Introduction

Animal welfare has taken centre stage in the last two decades, particularly in developed countries of western Europe and north America. Today, due to global and international trade, the need to ensure that animal welfare is observed not only rests with the developed world, but also the developing countries. In Zimbabwe, a beef producing and developing country, animal welfare is in its infancy. The livestock industry is taking a back seat despite increasing awareness by Zimbabwean veterinarians and animal scientists on deficiencies on legislation towards animal welfare (Welsh, 1997). The same author acknowledges that much of the current legislation in place is outdated, inadequate and inappropriate. For example, there are

deficiencies in legislation concerning slaughter of domestic animals, while the well-being of animals being transported is not adequately protected (Welsh, 1997). The latter is further aggravated by the fact that there is scanty published information (see Chambers, 1974; Thorton, 1975) on impact of pre-slaughter handling procedures of slaughter animals on their welfare as indicated by effects on carcass yield and meat quality. This information is vital for the sustained economic viability of the Zimbabwean beef industry. In addition, with the global interests in animal welfare and environmental issues, it is vital for the Zimbabwean beef industry to ensure animal welfare concerns are addressed as a measure to protect our international beef exports in the face of immense global competition.

It is recognized that compromised animal welfare *en route* to slaughter has a major economic impact on returns to the producer (Tarrant, 1990; Jarvis *et al*, 1995; Hoofbeats, 1995). It is estimated that approximately ten thousand tonnes of beef were downgraded or condemned in Zimbabwe in the year 1994 due to carcass bruising and occurrence of dark, firm, dry meat (DFD) (Hoofbeats, 1995). Economically, this cost the beef industry approximately 10 million Zimbabwe dollars. In the light of this, there is urgent need to substantially reduce such avoidable losses.

Bruising of cattle is one indicator of poor animal welfare manifested during pre-slaughter handling (Jarvis *et al*, 1995). Prior to retail, bruised tissue is trimmed which leads to a reduction in carcass yield, and often to downgrading. This in turn reduces monetary returns to the producer. As it is, bruising could potentially occur at the farm, during transport or at the abattoir. At the farm, during loading and unloading, there may be crowding and animals may fall, particularly on slippery floors, ultimately leading to bruising. There may be excessive use of sticks which culminates in bruising (Warriss, 1990). In addition, several authors report that agonistic interactions which occur on mixing unfamiliar cattle (social regrouping) prior to and during transport, are likely to lead to tremendous stress and subsequently increase susceptibility of animals to bruising and production of DFD meat (Thornton, 1975; McVeigh and Tarrant, 1983; Warriss *et al*, 1984; Tarrant, 1990). The effects are most profound in bulls than steers as the former are aggressive than the latter, and are likely to fight (Price and Tennessen, 1981; Tennessen *et al*, 1985), cows in heat (Kenny and Tarrant, 1987) as well as in horned than polled cattle (Thornton, 1975; Shaw *et al*, 1976; Wythes, 1985).

Increased transit mileage has also been reported to be associated with increased cattle bruising and exposure to varying degrees of stress (Chambers, 1974; Yea *et al*, 1978; Tarrant, 1990). Where the stress is chronic, the incidences of bruising (Barnett *et al*, 1984; McNally and Warriss, 1996) and DFD often referred to as dark firm cutting beef (DCB)

have been found to increase (Warriss, 1984; McNally and Warriss, 1996). The latter is due to depletion of glycogen reserves prior to slaughter (Warriss, 1990; Tarrant and Grandin, 1993). In this case, the reduction in glycogen reserves due to acute stress limits postmortem acidification leading to abnormally low concentrations of lactic acid which in turn leads to production of DFD meat. Typically, DFD meat has a high pH (above 5.8) whereas normal meat has a pH of 5.5. Dark, firm, dry meat is very dark in color, it has a firm texture and looks dry. When cut, the meat produces little or no exudate. The meat is prone to spoilage and has poor organoleptic qualities (Tarrant, 1990; Warriss, 1990; Tarrant and Grandin, 1993). The occurrence of DFD in slaughter cattle therefore reduces meat quality which in turn diminishes monetary returns to the producer. Since the occurrence of DFD, like bruising, is a consequence of pre-slaughter handling (Warriss, 1990), it is therefore important to educate the producer on advantages of ensuring that animal welfare needs are met, even when an animal is due for slaughter. It was with these considerations that, the study described in this paper investigated the incidences of bruising and DFD in Zimbabwean slaughter stock from a typical commercial abattoir during a four month period. The hypothesis was that there were no differences in occurrences of bruising and/or DFD among different classes of slaughter stock, i.e., steers, bulls and cows. Further, an attempt was made to relate transit distance to the incidence of bruising as well as to the frequency of occurrence of DFD. Here the hypothesis being tested was that an increase in transit mileage does not result in increases in incidences of carcass bruising and DFD in slaughter cattle.

Materials and methods

Animals and animal transportation

This study was carried out at a large commercial abattoir during and after December 1995, January, February and March 1996. In the study, a total of 9585 steers, bulls, and cows of the Hereford, Africander, Brahman, Jersey, Mashona

breeds and their crosses were used. All slaughter cattle used in this study were transported to the abattoir by road from commercial farms within a radius not exceeding 400 km of the abattoir.

Carcass evaluation for bruising and DFD

Carcass bruising and DFD were assessed by government meat grading inspectors according to commercial procedures used in Zimbabwe. Bruising was assessed by evaluation of and severity of discoloration of part, or the whole carcass (CSC Livestock Carcass Classification and Grading Regulations, 1995). As a common procedure, bruises were trimmed off where possible. In some cases, however, due to excessive and severe bruising, such carcasses were condemned. For evaluating DFD, the color of the meat was assessed visually while the texture or firmness of the *longissimus dorsi* muscle was assessed physically at the quartering point of the twelfth and thirteenth ribs.

Data analysis

Data were subjected to χ^2 -analyses to establish relationships between class of animal slaughtered and incidences of bruising as well as DFD. In addition, Pearson's correlation analyses were conducted using SAS procedures (SAS, 1994) to determine the relationship between transit distance and incidences of bruising and DFD. Linear regression analyses were done to determine rate of change in proportion of carcasses bruised in response to changes in transit distance as well as the degree of association between bruising and DFD.

Results

Table 1 shows that the percentage of steers that were bruised was less than the corresponding percentage of bulls and cows. The percentages of bruising were different ($\chi^2 = 58.0$; $P < 0.001$) between the three classes of slaughter stock (Table 1). Occurrence of DFD was significantly higher ($\chi^2 = 17.6$; $p < 0.001$) in bulls than in steers and cows, but was similar in steers and cows. Overall, carcasses from bulls had the highest damage while steers exhibited the lowest damage. However, it is important to take cognisance of the fact that the proportion of bulls slaughtered was very small compared to the other classes of animals.

The incidence of bruising was positively and directly related to transit distance ($r = 0.97$; $p < 0.05$). The lowest incidence of bruising (15 percent) occurred when animals were moved for less than sixty kilometers (Figure 1). From regression analysis, every additional increase of sixty kilometers in transit distance resulted in a 7 percent increase in bruised carcasses (regression equation: $y = 6.9 + 7.1x$; $R^2 = 0.96$; $p = 0.0047$ where y = percent carcasses bruised, 6.9 is the intercept, 7.1 is the regression coefficient and x = distance traveled in kilometers). Further, the occurrence of DFD was also directly related to transit distance ($r = 0.94$; $p < 0.05$). However, there was no association between percent carcass bruising and DFD occurrence ($p = 0.12$).

Table 2 shows that, the percentage of carcasses which exhibited DFD characteristics were different ($\chi^2 = 365.8$; $p < 0.001$) being highest in low weight carcasses and lowest in heavy carcasses (Table 2).

Table 1: Prevalence of bruising and DFD occurrence in carcasses from steers, bulls and cows slaughtered at a commercial abattoir.

| | Class of Slaughter Stock | | | Overall |
|--------------------|--------------------------|-------|-------|---------|
| | Steers | Bulls | Cows | |
| Number in survey | 4670 | 189 | 4726 | 9585 |
| Percentage bruised | 26.0a | 35.0b | 33.0b | 29.6 |
| Percentage DFD | 26.9a | 40.7b | 27.3a | 27.4 |

Figures in the same row with different superscripts are significantly different ($P < 0.05$).

Table 2: The influence of carcass weight (size) on incidence of DFD.

| | Hot carcass weight (kg) | | |
|------------------|-------------------------|-------------------|-------------------|
| | <100 | ≥100<250 | ≥250 |
| Number in survey | 3624 | 3701 | 2260 |
| Percentage DFD | 36.9 ^a | 21.2 ^b | 16.8 ^c |

Figures in the same row with different superscripts are significantly different ($p < 0.05$).

Discussion

The high proportion of bruised animals and a large proportion of carcasses being considered DFD beef indicate that animals were, indeed stressed at some point in time from the farm to the abattoir, suggesting that their welfare was compromised. McNally and Warriss, 1996 pointed out that, many conditions which cause bruising also predispose animals to stress. Stress in itself will enhance susceptibility of animals to bruising (Barnett *et al*, 1984). In turn, chronic stress can increase the incidences of DFD, so that the quality of the meat may be reduced in bruised carcasses (McNally and Warriss,

1996). The high incidence of DFD in our study, therefore, suggests that some of these animals might have been subjected to chronic stress. Invariably, such animals are expected to have experienced poorer welfare than other animals which did not show bruising.

The degrees, severity and proportions of bruised slaughter animals are variable among various reports (Tarrant, 1990; Jarvis *et al*, 1995, 1996; McNally and Warriss 1996, 1997). Recent work by (McNally and Warriss, 1996, 1997) reported very low incidences of bruising averaging 3 to 8 percent in a number of survey studies conducted in the United Kingdom. In comparison, the results in this study indicate a relatively high proportion of animals being bruised prior to slaughter. The differences between the results reported in this study compared to others mentioned above may be partly explained by the different ways of data collection and reporting, as well as differences in pre-slaughter management practices between countries.

Our findings that class or sex of animal has a significant effect on occurrence of bruising and of DFD (Table 1) concurs with

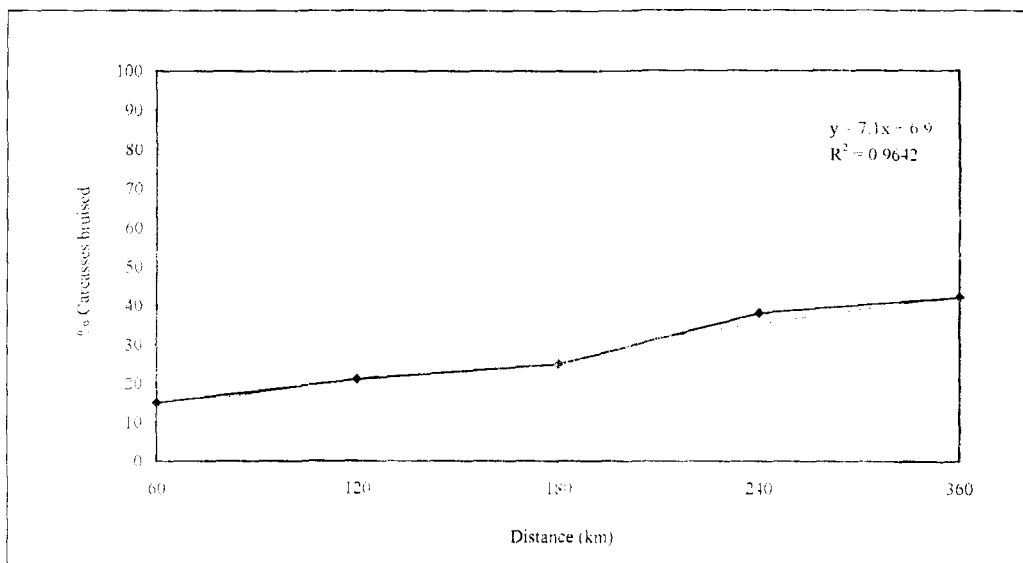


Figure 1: Relationship ($\Delta - \Delta$) between percent of carcasses bruised (Y-axis) and distance traveled in kilometers (X-axis) during transport to the abattoir. Line of best fit (-) and the regression equation: $y = 7.1x + 6.9$; $R^2 = 0.9642$.

observations by various other workers (Wythes *et al*, 1979; Price and Tennessen, 1981; Tennessen *et al*, 1985; Jarvis *et al*, 1995). In the current study, carcasses from bulls had more damage compared to steers and cows. According to McNally and Warriss (1996), such a finding is to be expected since the aggressiveness and agonistic behaviour of bulls predisposes them to bruising due to fighting and butting. Also social regrouping among young bulls leads to increased exhibition of mounting behavior (McVeigh and Tarrant, 1983; Warriss *et al*, 1984). The latter is intimately associated with glycogen depletion which leads to production of DFD meat (Price and Tennessen, 1981; Tennessen *et al*, 1985). However, our results are at variance with those of Wythes *et al*, (1985) and Jarvis *et al*, (1995) who reported lower bruising in young bulls than in steers or heifers. The differences may be attributed to a number of factors which include, numbers of animals used within the studies and differences in ages of bulls under consideration. In our study, relatively mature bulls were used.

In trying to explain the lower incidences of bruising and subsequently less meat being discarded from carcasses from young bulls than from steers and heifers as reported in some studies, McNally and Warriss (1996) were of the opinion that, owing to the aggressive nature of bulls, they are treated differently from the other classes of slaughter cattle. This would be expected to vary between farms and countries which could partly explain the disparities between studies from different countries.

Our results show that, distance traveled by slaughter cattle was highly correlated with bruising and DFD proportions. There was a tremendous increase in proportions of carcasses bruised when animals were transported for distances greater than 120 kilometers. These findings highlight a major problem in our beef industry, and the impact of transit distance on animal welfare. Although there is no consensus as regards the minimum distance that affects extent of cattle bruising, there is general agreement that excessively long distances (e.g., greater

than 500 kilometers) will result in increased incidences of bruising in cattle (Yeh *et al*, 1978; Wythes *et al*, 1981; Tarrant, 1990; McNally and Warriss, 1996). However, some studies have failed to establish a distinct effect of distance traveled by slaughter cattle on incidences of increased bruising (Jarvis *et al*, 1996; McNally and Warriss, 1997). But it is important to take cognizance of the fact that other factors like stocking density (Tarrant *et al*, 1988, 1992; Eldridge and Winfield, 1988), ventilation, standard of driving and standard of roads (Tarrant, 1988) will confound the effects of transit distance *per se*. This invariably leads to variability in results obtained between studies.

In studies where increased mileage has been reported to be associated with increased cattle bruising, the main reasons given were associated with animal distress and subsequent stress. Chronic stress, which normally would occur after some days of stress will lead to production of DFD meat (Barnett *et al*, 1984). In a review, Tarrant (1990) considered that the major hazard during cattle transport was the loss of balance resulting in cattle falling down during transportation, and the chances of this occurring are likely to increase as the duration of the journey increases. Earlier, Yeh *et al*, (1978) found that increasing the duration of the journey to between 3 and 10 days, resulted in more bruising in cows but not in steers. Tarrant (1988) reported an increase in the incidence of DFD in steers after long-haul transport. In Australia, Eldridge and Winfield (1988) found bruising in cattle to be significantly affected by transport conditions, such as space allowance. Tarrant (1990) also highlights the need for considerate and careful driving, use of good transport vehicles and indeed, the nature of the roads as important parameters affecting the degree and severity of bruising.

According to Grandin (1983), although the causes of bruising might be numerous, much of the bruising can be attributed to poor design of handling facilities, ignorant and abusive stockmanship and poor driving during actual transport. The standards of roads has a very important influence on

effects of transport on animal welfare (Tarrant, 1990). Work from Australia showed that beef heifers exhibited lower mean heart rates (indicating reduced stress) when the vehicle was traveling smoothly on highways compared with rougher country roads (Eldridge *et al*, 1981; Eldridge, 1988). Although the state of roads were not evaluated in this study, it is highly conceivable that driving conditions might have contributed substantially to the relatively high bruising incidences obtained. Road conditions are variable in Zimbabwe. They range from dirt tracks (gravel) on most farms to tarmac. It is highly possible that poor road conditions, particularly on dirt roads, and poor driving may explain some of the bruising observed on the cattle.

Although it was not feasible to evaluate carcass size according to breed, i.e., relate breed and carcass size to occurrence of DFD in this study, our results showed that lower carcass weights exhibited a higher incidence of DFD compared to medium and heavier carcass weights. This is in agreement with work from New Zealand where Graafhuis and Devine (1994) reported that lower carcass weights had higher pH (pH > 5.8: indicator of DFD) than heavier carcasses in beef animals. However, these authors failed to establish an effect of breed on ultimate pH of slaughter stock. Establishment of such an effect on Zimbabwean breeds will profoundly affect choices of breeds producers will use for beef production.

Implication to animal welfare

The relatively high incidences of bruising and DFD in slaughter cattle in this study are an indication that the welfare of a large proportion of animals was compromised prior to slaughter. The welfare of bruised animals is obviously poorer than that of animals not bruised. A large amount of bruising could be avoided if more care is taken when transferring animals from the farm to the abattoir. This will in turn translate into higher economic returns for the producers, while reduction in DFD will benefit the meat marketing organizations

within the country. However, further work is required to evaluate potential causes of bruising along the whole transport chain, from the farm to the abattoir.

It will also be interesting to evaluate the effects of breed on incidences of bruising and DFD.

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